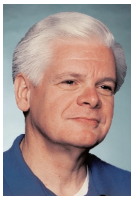
MACHINERY MESSAGES
CASE HISTORY

Electrostatic Discharge on a Compressor Train

Authored by:



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Generally, diagnosticians are aware of electrostatic discharge (ESD) phenomenon and its results. Nevertheless, it is suspected that relatively few have had the opportunity to observe the ill effects of ESD on the vibration-related behavior of a machine. While most are aware that this problem can occur on motors and generators, it can also affect non-electrical machinery, such as the machine train that is the subject of this case history.

Background

Data from a Dynamic Data Manager® system at a chemical plant in a Pacific Rim country was recently transmitted to Bently Nevada's machinery diagnostic services personnel. The customer was seeking advice regarding unusual observations with a machine train. Summarized in Figure 1, the train consists of a steam turbine as a prime mover (8750 rpm), driving a low-pressure (LP) compressor with double shaft extensions. The LP compressor was coupled to a speed-increasing gearbox to drive a high-pressure (HP) compressor (13,307 rpm). All the elements of the machine train were equipped with XY proximity probes, including the gearbox shaft extensions. Low-speed shaft bearing clearances on the gearbox are 229 µm (9 mils) nominal and the high-speed bearings are 203 µm

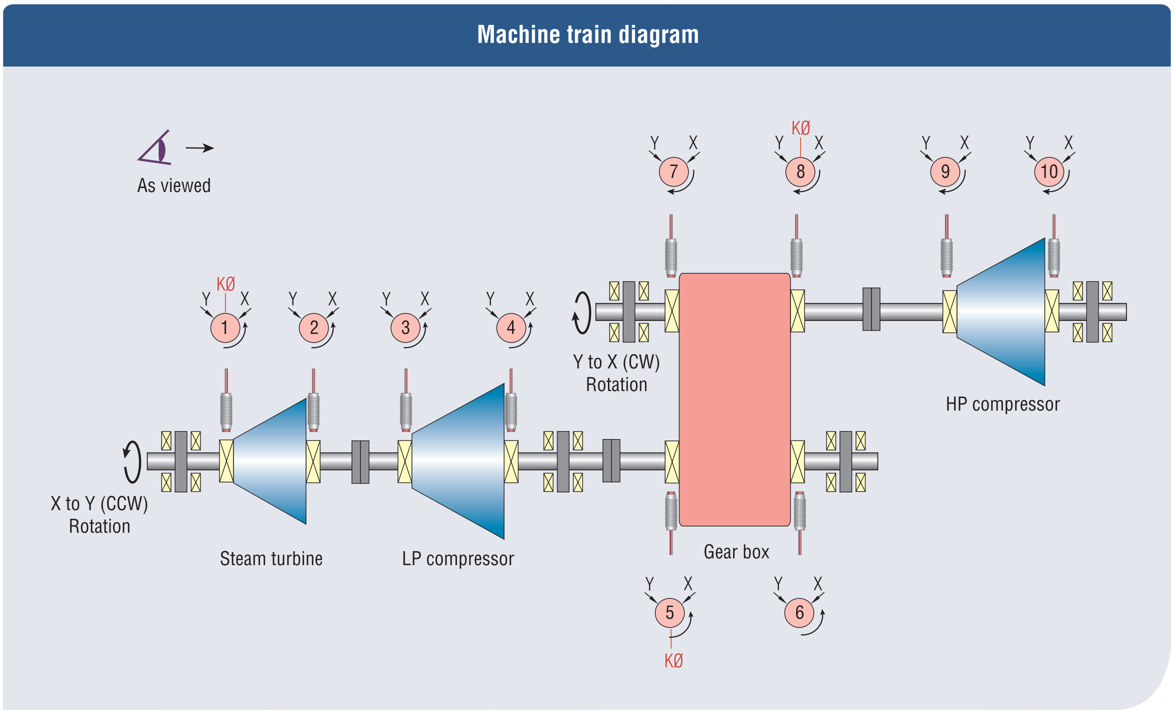

Figure 1.

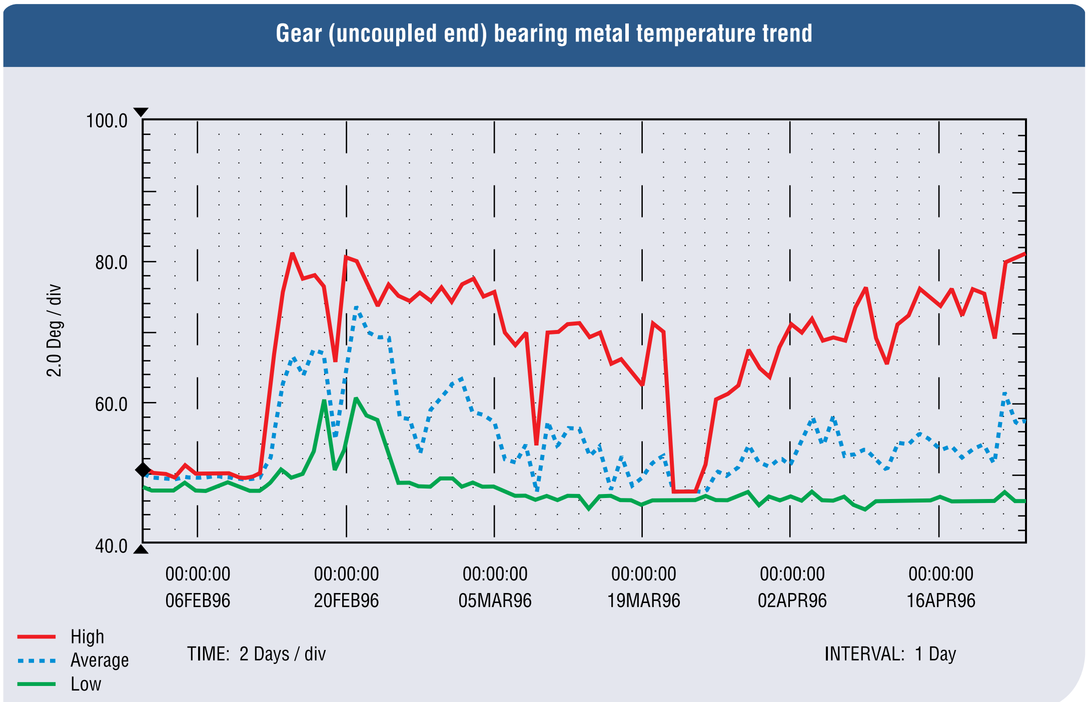

Figure 2.

(8 mils) nominal. Gearbox arrangement is “downmesh”; i.e., the pinion is driven down and the gear wants to move upward.

The customer reported that the train was placed in service in October 1993. From that time until 1 February 1996, the machine train operated trouble free. However, from 1 February 1996 to 24 April 1996, gradual changes in 1X amplitude, phase, and shaft centerline position were observed at the gearbox low-speed shaft extension. Additionally, an approximate 10 °C (50 °F) temperature increase had also been observed on the radial bearing on the uncoupled end of the gearbox low-speed shaft. Other temperatures, centerline information, and trend plots were relatively insignificant. Plots showing the most pertinent data are referred to by number in the remainder of this discussion.

Observations

Figure 2 shows the trend of bearing metal temperatures at the gearbox low-speed “blind” (uncoupled end) radial bearing (Bearing 6 in Figure 1). The plot shows a marked increase in temperature on or about 12 February as well as a very slight upward trend starting in late March. Significant and of short duration decreases in temperature are due to scheduled shutdowns or process changes affecting machine load.

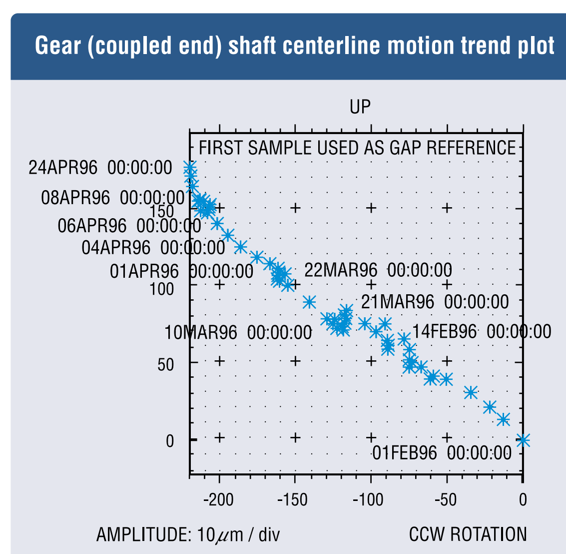

Figure 3.

Figure 3 is the plot of shaft centerline motion at the gearbox low-speed shaft extension bearing (Bearing 5 in Figure 1). The plot indicates approximately 280 μm (11 mils) shaft movement since 1 February 1996. This is an excess of 25% from the nominal bearing clearance of 229 μm (9 mils).

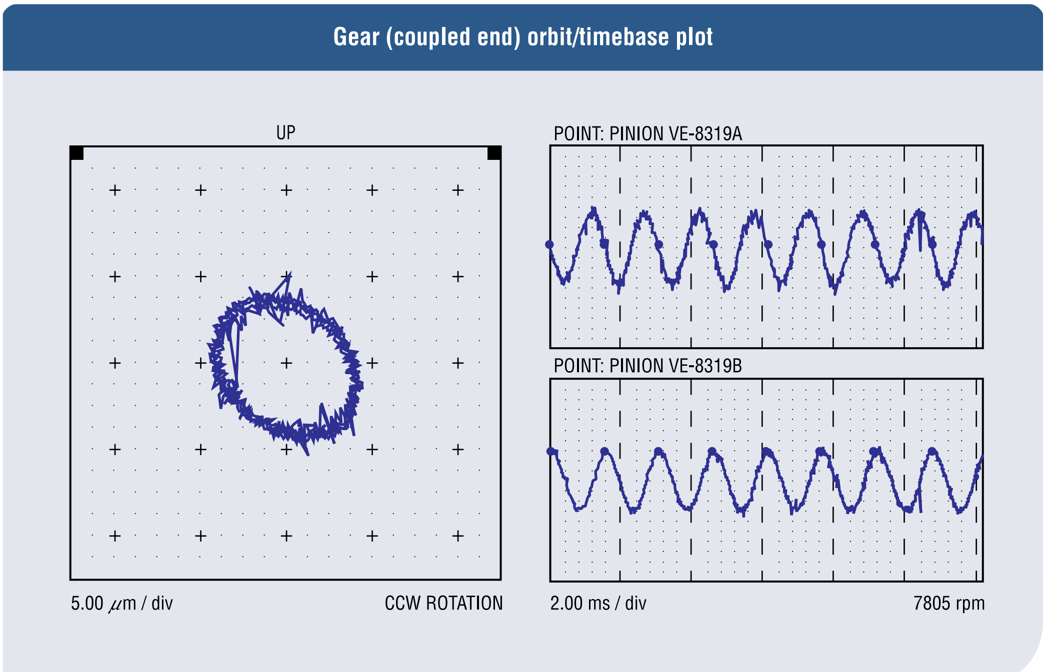

Figure 4.

Figure 4, the orbit/timebase plot at the gearbox low-speed shaft extension (Bearing 5), looks relatively insignificant with the exception of some occasional spiking which could be interpreted as a loose probe or electrical connection in the signal path. As will be seen, this was later attributed to electrostatic discharge rather than loose transducer connections or wiring.

Figure 5 shows an orbit/timebase plot, this time from the pinion extension bearing (Bearing 8). Note the evidence of pronounced spiking. Also note that the spiking is clearly random and shows both positive and negative excursions, therefore ruling out a scratch in the probe target area.

The balance of the orbit/timebase plots from the machine train also showed slight hints of spiking.

The presence of random spiking at multiple proximity probes throughout the machine train discounted the possibility of loose probes or electrical connections in the signal path. Electrostatic discharge was a high probability, particularly in light of the significant shaft centerline motion observed at the gearbox low-speed shaft extension bearing. Recall that gearbox bearings under full load operate at eccentricity ratios of 0.80 to 0.85, often yielding minimum oil film thicknesses of 38 µm (1.5 mils). Thus, in

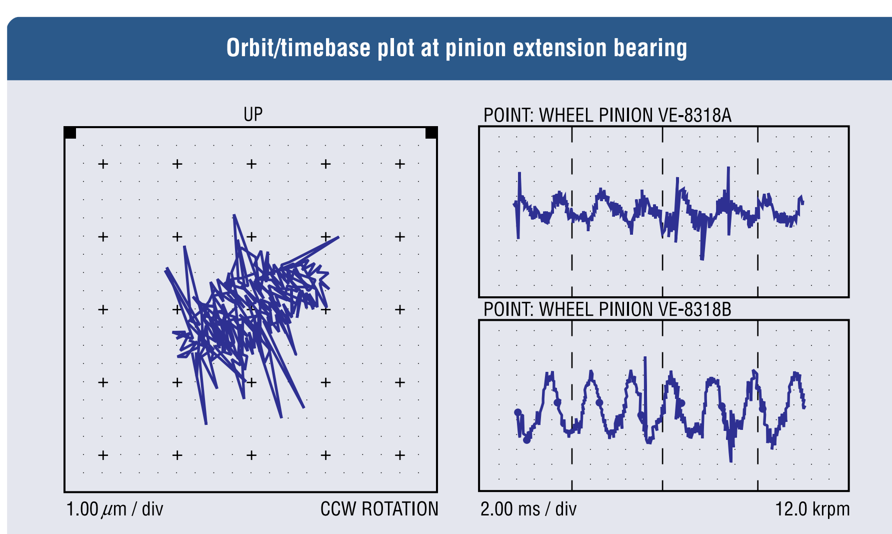

Figure 5.

a machine train that includes a gearbox, electrostatic discharge is likely to be at its worst at the gearbox bearings since this represents the shortest path to ground.

Recommendations and Findings

The customer was advised to schedule a shutdown for internal inspection at the earliest opportunity and certainly before the total shaft movement exceeded the equivalent of 380 µm (15 mils), approximately 50% over bearing nominal clearance. During a planned shutdown, the customer opened the gearbox for inspection. All the gearbox bearings were severely pitted due to electrostatic discharge and deemed unacceptable for further use. Both compressors were likewise opened for inspection and all bearings and seal rings were found to be pitted. Only one bearing exhibited pitting in the steam turbine. All the distressed bearings and seal rings had to be replaced.

Root Cause

Upon inspection of the grounding brush assembly, one of two brushes did not show contact with the shaft and the other was stuck inside the assembly, preventing contact. The grounding brush assembly was essentially ineffective.

Summary

Electrostatic discharge can be an especially damaging phenomenon, as shown in this case history where nearly every bearing and seal in the machine train had to be replaced. Also, it is not limited to just motors and generators; it can also affect non-electrical machinery. The remedy is generally simple – regular inspection of the brushes and voltage mitigation equipment to ensure that they are working properly, and use of vibration and position data already available on most machines to determine if damage is occurring. A companion article on page 23 of this issue of ORBIT discusses monitoring strategies for detecting this phenomenon.